

REMARKS

Further and favorable reconsideration is respectfully requested in view of the foregoing amendments and following remarks.

Claim 1 has been amended to recite a method of manufacturing an oxide dispersion strengthened martensitic steel excellent in high-temperature strength, and claims 1-4 have been amended to more particularly recite the methods. Support for these amendments is found on page 9, lines 3-15 and page 15, lines 2-6 of Applicants' specification. Additionally, minor changes of an editorial nature have been made to the claims.

New claim 5 has been added to the application, and is drawn to the same subject matter as amended claim 1, except the weight % of Y_2O_3 is 0.34% to 0.5%. Support for this lower value is found in Table 2, on page 14 of Applicants' specification, which indicates the chemical compositions of test materials prepared in the Test Example.

The patentability of the present invention over the disclosures of the references relied upon by the Examiner in rejecting the claims will be apparent upon consideration of the following remarks.

The rejection of claims 1 and 4 under 35 U.S.C. § 103(a) as being unpatentable over Lambard et al. is respectfully traversed.

The Examiner takes the position that Lambard et al. disclose a martensitic alloy based on iron and chromium strengthened by a dispersion of oxides. The Examiner admits that Lambard et al. do not specifically teach adjusting the Ti content within the range of 0.1 to 1.0% so that an excess of oxygen content in the steel satisfies the claimed formula. However, the Examiner asserts that when prior art compounds essentially "bracketing" the claimed compounds in structural similarity are all known, one of ordinary skill in the art would be motivated to make those claimed compounds in searching for new products in the expectation that compounds similar in structure will have similar properties.

It is generally believed that the strength of an oxide dispersion strengthened (ODS) martensitic steel depends on the content of Y_2O_3 contributing to dispersion strengthening, as well as other additive elements (W, Ti, C, etc.) for strengthening. However, Applicants have discovered that an excess oxygen content (Ex.O)

contaminated into the steel during the manufacturing process significantly affects the dispersion condition of the oxide particles in ODS martensitic steel, as well as the high-temperature strength thereof. Further, Applicants have discovered that the high-temperature strength of the ODS martensitic steel can be positively improved by adjusting the contents of Ex.O and Ti in the steel to within a predetermined range. (See page 3, lines 8-16 of Applicants' specification).

In Applicants' amended claim 1, the oxide particles (nanometer-order) are finely dispersed and highly densified in the matrix in order to effectively improve the high-temperature strength of the ODS martensitic steel, by adjusting the Ti content within the range of 0.1 to 1.0 % so that Ex.O in the steel is within the limited range. Applicants' invention, as set forth in amended claim 1, is based on the finding that a slight fluctuation in Ex.O and Ti contents significantly affects the dispersion condition of oxide particles in ODS martensitic steel and the high-temperature strength thereof.

The control of the Ex.O content in Applicants' invention is carried out at a very small level, such as 0.01 to 0.1 wt %. In the general manufacturing process of ODS martensitic steel, as used in the present invention, the content of contaminated Ex.O is fluctuated for every manufacturing batch, and therefore it is difficult to satisfy the limited range of Ex.O as defined in Applicants' amended claim 1. In order to effectively control the small amount of Ex.O to the limited range, Applicants use Ar gas having a purity of not less than 99.9999 % as the Ar atmosphere (claim 2). Further, Applicants decrease the stirring energy during the mechanical alloying treatment (claim 3), and use a metal Y powder or a Fe₂Y powder in place of the Y₂O₃ powder (claim 4).

Lambard et al. disclose a method of manufacturing a ferritic or martensitic ODS alloy having high-temperature strength by increasing grain size. Specifically, a martensitic ODS blank obtained by mechanical alloying is subjected to at least one thermal cycle comprising an austenitization of the martensitic ODS blank at a temperature greater than or equal to the AC3 point of this alloy, to obtain an austenite, followed by cooling the austenite at a slow cooling rate that is less than or equal to the critical cooling rate for transformation of the austenite into ferrite, to obtain an alloy

with a ferritic ODS structure having a large grain size, such as 3 to 8 micron mean grain size. (See column 3, lines 13-26, column 5, lines 20- 26 and claim 1 of the reference.) Then, a martensitic ODS alloy is manufactured by subjecting the obtained ferritic ODS structure to a martensitic transformation step, followed by a tempering of the manufactured martensitic ODS alloy. (See claim 17 of the reference.) Therefore, the martensitic ODS alloy is manufactured through at least a two step heat treatment. The mean grain size of the manufactured martensitic ODS is equivalent to that obtained in the ferritic ODS structure. (See column 7, lines 54- 60 of the reference.)

In contrast, according to the method of Applicants' amended claims 1 and 4, the martensitic ODS steel is manufactured using a general manufacturing process comprising a mechanical alloying treatment, hot extrusion and a final heat treatment involving normalizing and tempering. Therefore, Applicants' methods of claims 1 and 4, which employ only a one step heat treatment, differ from the method of Lambard et al., in which at least a two step heat treatment (including the specific thermal cycle) is employed to manufacture martensitic ODS alloy having a large grain size.

Further, as admitted by the Examiner, Lambard et al. do not teach or suggest adjusting the Ti content within the claimed range so that the Ex.O content in the steel is within the claimed range, as recited in Applicants' claims. Nor do Lambard et al. disclose or suggest that the contents of Ex.O and Ti in the steel significantly affect the dispersion condition of the oxide particles in ODS martensitic steel and the high-temperature strength thereof. The reference also fails to teach or suggest that by adjusting the Ti content within the range of 0.1 to 1.0 %, so that the Ex.O content in the steel is defined within the claimed range, the oxide particles can be finely dispersed and increased in number in the matrix, thereby drastically improving the high-temperature strength of ODS martensitic steel.

The following Table A compares the high-temperature strength of the ODS martensitic steel (material T5) manufactured by the method recited in Applicants' claim 1 with the martensitic ODS alloy of Lambard et al. (EM10+Y₂O₃ -ODS disclosed

Example 5, Table 5).

Table A

Material		Tensile strength (MPa)		
		650 °C	700 °C	750 °C
Lambard et al.	EM10+Y ₂ O ₃ -ODS	331		205
Material of Invention	T5		353	
	E5		384	
Reference material	Y1		278	

As shown in Table A, the tensile strength of the material T5 at 700 °C (353 MPa, as shown in Fig. 8B of Applicants' specification) is remarkably higher than that of Lambard et al. (331 MPa at 650 °C and 205 MPa at 750 °C). In general, when the test temperature increases by 50 °C, the tensile strength of a heat resisting steel is remarkably reduced. In spite of such a tendency, the tensile strength at 700 °C of the material T5 is higher than the tensile strength at 650 °C of the Lambard et al. material. In a case, as described above, where the difference in high-temperature strength between two kinds of steels is so large, it cannot be said that these steels have a similar high-temperature property from a technical viewpoint.

The reference material Y1 in Table A is ODS martensitic steel having Ex.O content of 0.026 wt% (see Table 4 on page 22 of Applicants' specification) which is too small to satisfy the predetermined range of Ex.O defined in claim 1. Specifically, Ti = 0.20% in reference material Y1. Therefore, Ex.O must be between 0.044% (0.22 x Ti) and 0.092% (0.46 x Ti). The Ex.O content in reference material Y1 (0.026 wt%) is too low to satisfy Applicants' claim 1. The tensile strength at 700 °C of the reference material Y1 has a value of 278 MPa (see Fig. 8B of Applicants' specification) which is much lower than the value for the material of the Applicants' invention. By comparing the high-temperature strength of material T5 with the reference material Y1 and EM10+Y₂O₃ -ODS of Lambard et al., it is clear that the Applicants' invention, as set forth in amended claim 1, has an improved effect in high-temperature strength that is not taught or suggested by Lambard et al.

Regarding claim 4, the Examiner asserts that Lambard et al. teach employing yttrium powder in the starting powder. However, as described above, Lambard et al. do not disclose or suggest adjusting the Ti content within the claimed range so that the Ex.O content is within the claimed range. Nor do Lambard et al. disclose or suggest that the Ex.O content in the steel significantly affects the dispersion condition of the oxide particles in ODS martensitic steel and the high-temperature strength thereof. Further, Lambard et al. do not teach that by using Y powder or a Fe₂Y powder in place of the Y₂O₃ powder, so that Ex.O in the steel is defined within the claimed limited range, the oxide particles can be finely dispersed and highly densified in the matrix to effectively improve the high-temperature strength of ODS martensitic steel.

Therefore, Lambard et al. do not teach or suggest a manufacturing process as set forth in Applicants' claims 1 and 4.

The rejection of claim 2 under 35 U.S.C. § 103(a) as being unpatentable over Lambard et al. in view of Taguchi et al. is respectfully traversed.

The Examiner asserts that Lambard et al. disclose the method for making oxide dispersion strengthened martensitic steel substantially as claimed by Applicants. The Examiner admits that Lambard et al. do not teach mechanically alloying the starting powder and oxide in an Ar gas having a purity of not less than 99.9999%. The Examiner asserts that Taguchi et al. teach that the presence of O, C and N introduced during mechanical pulverizing affect the particle boundaries of starting powder, which causes embrittlement of the materials. The Examiner asserts that it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize a high-purity argon atmosphere during the mechanical alloying of the powder as taught by Lambard et al., to avoid the presence of free O, C and N. Lastly, the Examiner states that where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable range by routine experimentation.

Taguchi et al. disclose a ferritic steel with high-strength and high-toughness, and a method of producing the steel. As stated above, Taguchi et al. note the presence of free O, C and N included as impurities during the mechanical pulverizing process, which affects particle boundaries of the starting powder to cause embrittlement of the materials. Taguchi et al. overcome this defect by adding at least one element selected

from Ti, Zr, Hf, V and Nb to reduce the content of O, C and N and improve the toughness of the product steel. As pointed out by the Examiner, Taguchi et al. also teach that inclusion of O, C and N during the mechanical pulverizing process can be suppressed to some extent by using a high-purity inert gas in gas atomization and mechanical pulverization process. (See column 4, lines 22-36 of the reference.) However, the ferritic steel of Taguchi et al. is not the same as ODS martensitic steel, as recited in Applicants' claims, and therefore a discussion of the Ex.O content in the steel, which affects the dispersion condition of the oxide particles in ODS martensitic steel is not necessary.

Furthermore, Taguchi et al. disclose a method for improving toughness and room temperature strength by reducing the contents of O, C and N and making grain size finer. Finer grain size is generally known to improve room temperature strength, and to degrade high-temperature strength. On the contrary, Lambard et al. teach a method of manufacturing a martensitic steel having a high temperature strength by increasing grain size. Therefore, the method of reducing the contents of O, C and N, as taught by Taguchi et al., would defeat the very purpose of the process disclosed by Lambard et al., and accordingly, combining the teachings of these references is improper. Ex parte Hartmann 186 USPQ 366.

Furthermore, the effect of the method of Applicants' claim 2 is demonstrated in Table A (as shown again below).

Table A

Material		Tensile strength (MPa)		
		650 °C	700 °C	750 °C
Lambard et al.	EM10+Y ₂ O ₃ -ODS	331		205
Material of Invention	T5		353	
	E5		384	
Reference material	Y1		278	

Specifically, the tensile strength at 700 °C of material E5 (384 MPa as shown in Fig. 8B of Applicants' specification) manufactured by the method of claim 2 is higher than that

of the reference material Y1 (278 MPa as shown in Fig. 8B of Applicants' specification) which was not manufactured by the method of claim 2.

Additionally, the following Table B compares the high-temperature creep rupture and rupture stress at 1000 hours of the material E5 with the reference material Y1.

Table B

Material	time to rupture (hr) (stress: 120 MPa)	rupture stress (MPa) at 1000 hr
Material of Invention E5	4614	130
Reference material Y1	199	100

Specifically, when the stress of 120 MPa is added, the time to rupture of the material E5 (4614 hours as shown in Fig. 7A of Applicants' specification) is remarkably longer than that of the reference material Y1 (199 hours as shown in Fig 7A of Applicants' specification). On the other hand, the rupture stress at 1000 hours of the material E5 (130 MPa as shown in Fig. 8A of Applicants' specification) is improved by 30 MPa in comparison with that of the reference material Y1 (100 MPa as shown in Fig. 8A of Applicants' specification). This demonstrates that the life time of the material E5 is 23 times longer than that of the reference material Y1.

Combining the teachings of Lambard et al. and Taguchi et al. is improper for the reasons stated above. Further, neither reference teaches or suggests the method of Applicants' claim 2, in which the Ex.O content in steel is controlled within the limited range by using a high-purity Ar gas having a purity of not less than 99.9999 % as the Ar atmosphere, thereby finely dispersing the oxide particles and increasing their number density in the matrix of ODS martensitic steel in order to improve high-temperature strength. Therefore, the method of Applicants' claim 2 is unobvious over the combination of Lambard et al. and Taguchi et al.

New claim 5, which requires a Y_2O_3 content of 0.34 to 0.5%, is patentable over the cited references for the same reasons claim 1 is patentable. Further, claim 5 is

patentable because neither of the cited references teach or suggest this claimed range of Y_2O_3 .

The allowance of claim 3 is noted.

Therefore, in view of the foregoing amendments and remarks, it is submitted that each of the grounds of rejection set forth by the Examiner has been overcome, and that the application is in condition for allowance. Such allowance is solicited.

Respectfully submitted,

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